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FINAL MILESTONE REPORT

PROGRAMME	Longevity of Current Mines (LoCM)	**WORK PACKAGE**	LoCM22WP3.4: Electronic integrated planning and reporting systems
MILESTONE	Final close-out report		

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Contents

1 EXECUTIVE SUMMARY

This close out report for the LoCM WP3 research project, titled "*Electronic Integrated Planning and Reporting System (Phase II)*", forms part of the scoping of the SAMERDI Longevity of Current Mines (LoCM) research programme. This LoCM WP 3 research project has aimed to develop a mine planning operational management concept for implementation with a future electronic integrated planning and reporting System. This research project commenced with the elicitation of the future planning requirements, then progresses towards the definition of a conceptual planning business model and processes. Once a mine planning business model was available, a mapping to the ISA95 solution model was performed. The ISA95 solution model was henceforth implemented as an integrated Enterprise Resource Platform (ERP) at two Sibanye-Stillwater operational shafts in the Rustenburg and Marikana areas.

2 AIM OF THE RESEARCH PROGRAMME

The aim of this LoCM WP3 programme was to adapt existing OEM planning solutions for the purpose of implementing a possible future integrated planning solution at a mining pilot operation. Collaboration with willing OEMs shall be leveraged to adapt legacy planning solutions in order to implement as many as possible of the future planning processes identified in requirements stakeholder work sessions. The implementation of an integrated planning solution at two Sibanye-Stillwater operational sites i.e. Rustenburg- and Marikana shafts were performed. The implementation was performed in collaboration with OEM suppliers, with the collective objective of implementing similar pilot integrated planning solutions at both the "Khomanani" and "Saffy" shaft operations. The two pilot implantations upgraded the current Sybanye-Stillwater planning systems, which previously focussed mostly on the strategic operational level, to a fully integrated Enterprise Resource Planning (ERP) platform-based solution, also integrating the short-horizon planning requirements down to the shift level. This integrated platform is vendor agnostic and has the capability to collate data from the various disciplines spatially distributed over the Sibanye-Stillwater mining operations.

3 METHODOLOGY USED

The requirements elicitation, definition of a functional concept and establishment of an integrated Enterprise Resource Platform (ERP) at two Sibanye-Stillwater sites entailed the establishment of the requirements, the solution platform framework required as well as a pilot implantation at two operational shaft sites. The objective was to verify the integrated capabilities to perform short term-planning processes for the wider adoption by all Sibanye-Stillwater operations. The methodology followed in this research project was:

3.1 Step 1: Conduct requirements elicitation work-sessions

The Sibanye-Stillwater management has, as early as 2021 identified the need to develop short-horizon planning capabilities. The need for automated planning processes with a granularity down to the daily shift level was required. This stage explored the theoretical context of short-horizon operational planning requirements in the mining context. Planning management has, in the past, mostly focussed on strategic and tactical level planning capabilities, with short-horizon, daily and shift level planning was mostly performed manually with defragmented data in spreadsheet format. Planning at this level

was hence slow and error prone, providing the rationale to explore improved short-term planning practices.

3.2 Step 2: Definition of a functional implementation model

Once planning management requirements were identified, requirements could be allocated to a possible solution framework architecture to guide the eventual implementation effort. The availability of a solution framework enabled the collaboration with OEM suppliers for the implementation of an integrated ERP system, which resulted in the creation of a single planning database capability mainly to support automated short-term planning practices for planning managers to automate planning as well as the updating of plans due to the availability of resources.

3.3 Step 3: Implementation at two pilot implementations at Sibanye-Stillwater a mining shaft

The willingness of various OEM suppliers and Sibanye-Stillwater enabled the pilot implementation of the planning capability. Two pilot sites at Rustenburg Khomanani- and Marikana Saffy shafts were identified as representative operations to commence with a pilot implementation. The strategic intent was that, once the pilot implementations were verified and validated, that the solution would be rolled out to other Sibanye-Stillwater operations.

4 RESULTS

4.1 Conduct requirements elicitation work-sessions.

During requirements elicitation work-sessions, eight (8) key functional capabilities (F1 to F8) have been identified as minimum capabilities to be integrated for the establishment of a future operational integrated planning capability.

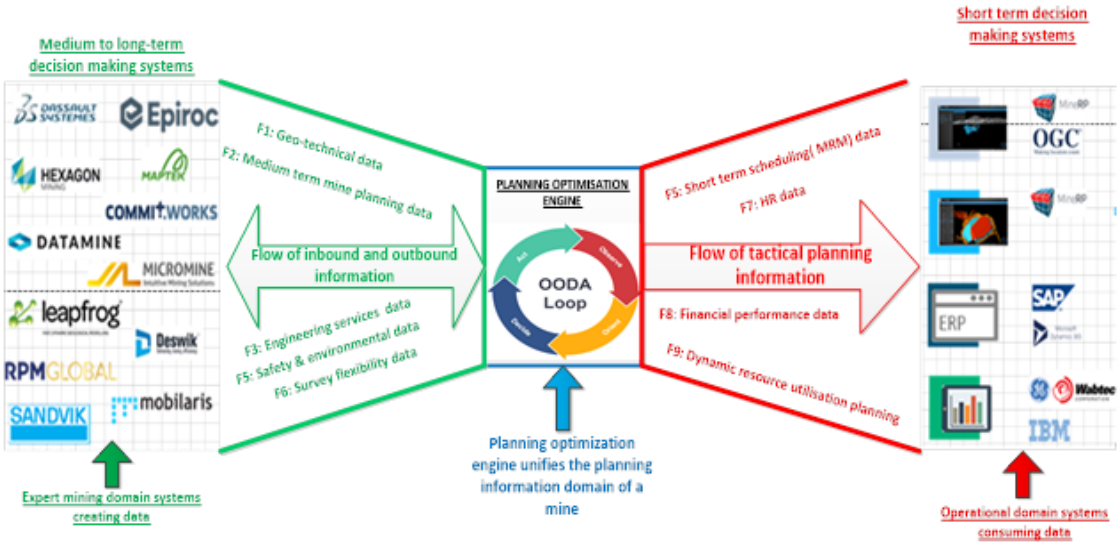

Figure 1: Long- and short-term functional capabilities

The integration of the long-term functional (F1, F2, F3, F5 and F6) capabilities (Figure 1) , with the required short-horizon capabilities (F4, F7, F8, F9) would be key to the success of a future pilot ERP platform implementation. The standardises information flow between these functionalities would enable the establishment of a single database to be used for planning process. The incorporation of

the eight functional capabilities can be incorporated within a future concept of operation concept for an agile OODA-loop planning capability, as depicted in Figure 1.

The relevance of this, is that the basis for the development of a more detail set of requirements are now possible, which implies that the technologies and capabilities of OEM suppliers to realise an integrated planning solution that for adoption by RSA mines in the imminent future is now a realisable possibility.

4.2 Definition of a functional implementation model

The definition of a functional implementation model would require the identification of the key required planning business processes. For this purpose, the Federal Enterprise Architecture Framework (FEAF) analysis method could be used to identify high-level processes. The FEAF framework is an USA defined approach which provides a common approach for the integration of strategic, business and technology management as part of organizational design and performance improvement. This Federal Enterprise Architecture Framework (FEAF) equips any industry, such as a mining operation with a common language and framework to identify, analyse and describe required future business processes, such as i.e. planning processes.

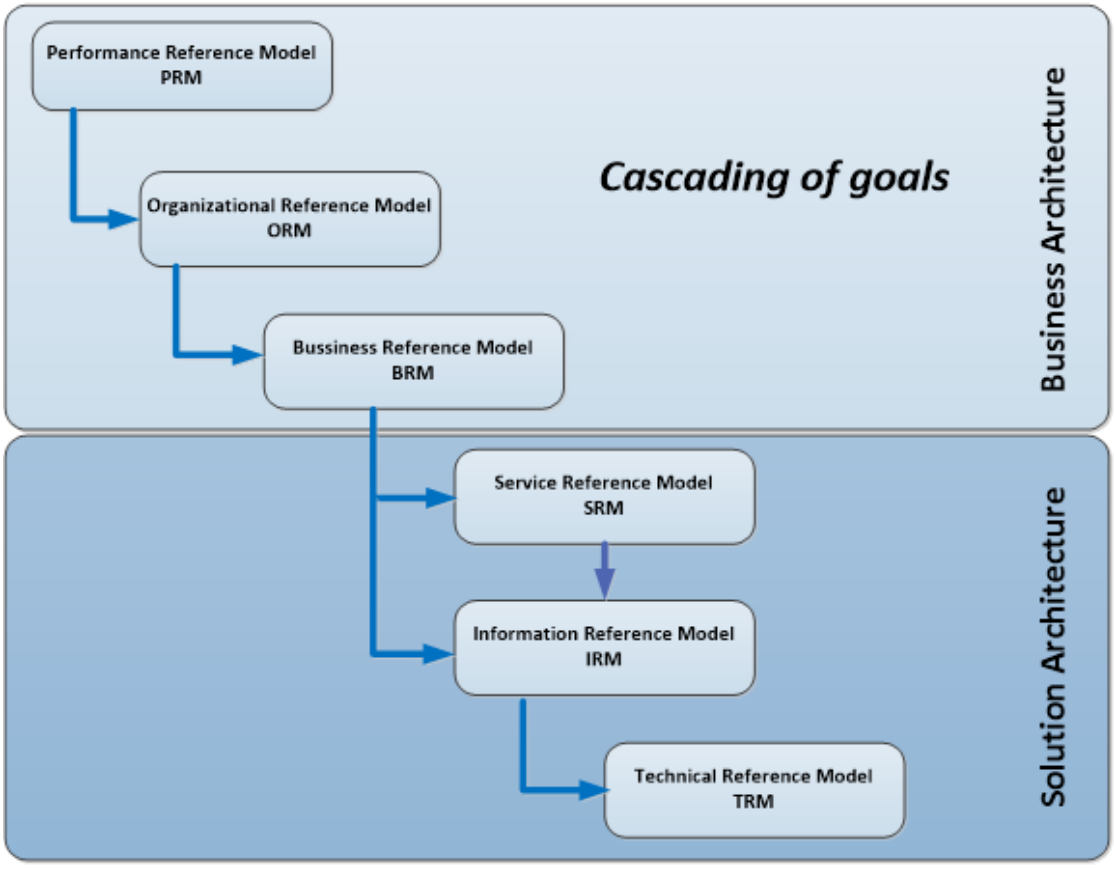

Figure 2: The FEAF cascaded modelling process.

The FEAF model consists of a set of interrelated reference models designed to facilitate cross-agency analysis and the identification of duplicative investments, gaps and opportunities for collaboration within and across various organisational specialisation domains. Collectively, the reference models comprise a framework for describing important elements of mining operations in a common and consistent way. Using the FEAF approach and its vocabulary, Information Technology (IT) portfolios

can be better managed and leveraged across the various organisational disciplines, enhancing collaboration and ultimately transforming the organisation to function in a more integrated state.

This FEAF Business process analysis approach must be performed in a way that describes the elements of the Business Architecture adequately. Therefore, a method is proposed that is described in the Federated Enterprise Architecture and widely used as a practical method to derive mining business requirements in a way that is interrelated. It derives the various architecture domains in a specific sequence to ensure the cascading of goals (Figure 1) in terms of interrelated appropriateness, completeness and accuracy. It is categorised as reference models, meaning it refers to a predefined structure used as reference to derive appropriate content.

In this research project the Performance Reference Model (PRM) was compiled (Figure 3) to analyse the required business processes. The PRM identifies the objectives to be considered during project execution in the form of Key Performance Areas (KPA's), Key Performance Indicators (KPI's), Controls and Risks. These are used to track benefit and to measure appropriate results. It is essential to note that selecting the incorrect performance reference, will cause a ripple impact. This is because the fit-for-purpose architecture will be defined to support an incorrect performance objective. The formulation of an operating model in which the mine architecture is scoped also forms part of this reference.

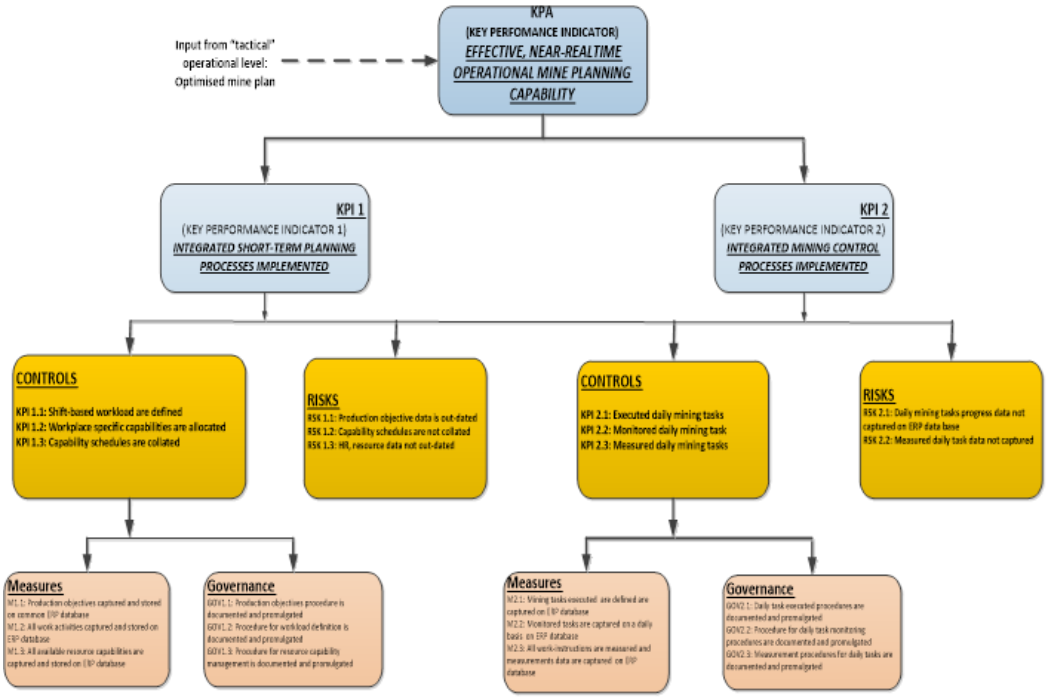

Figure 3: The cascaded planning PRM model.

5 RESEARCH FINDINGS

5.1 Research Finding

The implementation of an ERP platform (Figure 4) requires the integration of all the mining specific domain technology databases from Geology, Planning, Engineering, Volumetrics, Safety, environment and telemetry into a single database. The implication is that planning operations could be implemented by using a single database which is created with one view of the operational "truth".

The collation of medium to long-term mine planning data from the strategic levels onto a ERP platform allows for the generation of daily shift level schedules which is made available to the various operational level mine operation stakeholders.

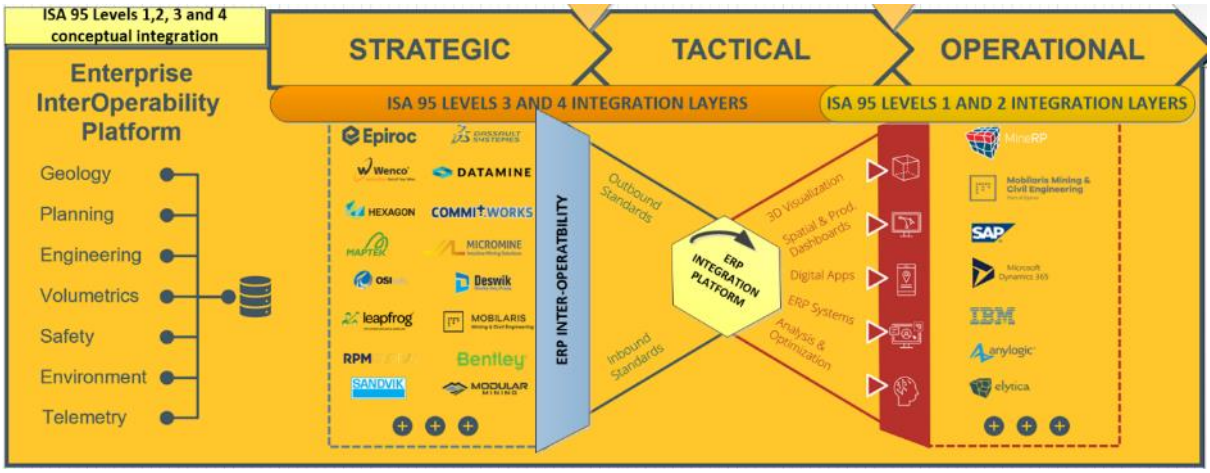

Figure 4: The integrated ERP platform model

5.1.1 Research Outcome 1 as applicable

The definition of a multi-tier mine communications network (Figure 5) was essential for the adoption of digitised platforms at Sibanye_Stillwater. Digitised planning functions requires the availability of near-real-time data to enable the compilation of automated schedules, and hence to update schedules when resource availability changes. A conceptual solution architecture was defined as illustrated in Figure 5. This figure depicts a typical future ERP system integrated mine scenario with connectivity over all four layers of an ISA 95 solution.

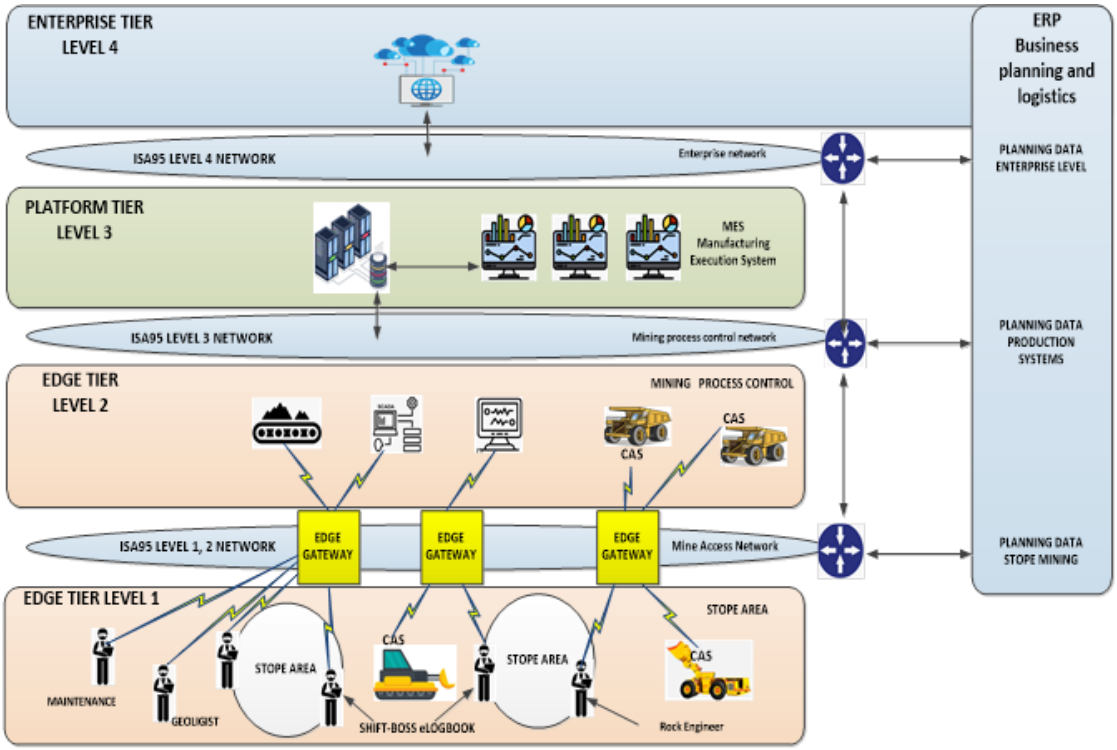

Figure 5: Solution communications architecture

Levels 1 and 2 are the stope mining and process control layers of the mining process. These layers provide the" raw" near real time data from the stope-face via edge gateway interfaces which are connected to the backbone mine access network. The Near real-time operational planning processes can be implemented as data is available on a shift-by-shift basis from various connected information sources at the stope area, such as from geologists, rock engineers, shift-boss's, maintenance and connected vehicle resources. The accuracy and timeliness of the data enable ERP systems to generate and change operational planning information as required, with the ability to communicated planning information to the stope-face to mobile devices as required.

5.2 Implementation at two pilot implementations at Sibanye-Stillwater a mining shaft

The pilot integrated ERP solution platform adopted at Sibanye-Stillwater Khomanani and Saffy shafts utilised the international ISA 95 solution implementation framework, to conceptually implement their integrated solution. The lead OEM supplier, MineRP , was selected to be the core integration platform, which provided open interfaces for the integration of the legacy systems, hence re-utilising these investments, in developing a new solution architecture. The MineRP ERP platform implements a strategic, tactical and operational (short horizon) set of planning capabilities, which maps well to the ISA 95 framework levels.

The final integrated operational solution could be mapped (Figure 10) to the ISA 95 framework to illustrate the integration interfaces of the various OEM suppliers. The "MineRP integrated spatial framework" platform is depicted as an integration block placed over layers 2 and 3 of the ISA 95 framework. The Sandvik/Deswik and SCADA integration platforms are functioning mostly over layers 1 and 2, integrating the plant control and supervisory systems. The SCADA and Sandvik/Deswik systems do interface with the MineRP platform via an open interface standard to contribute towards the near real-time database managed by the MineRP platform.

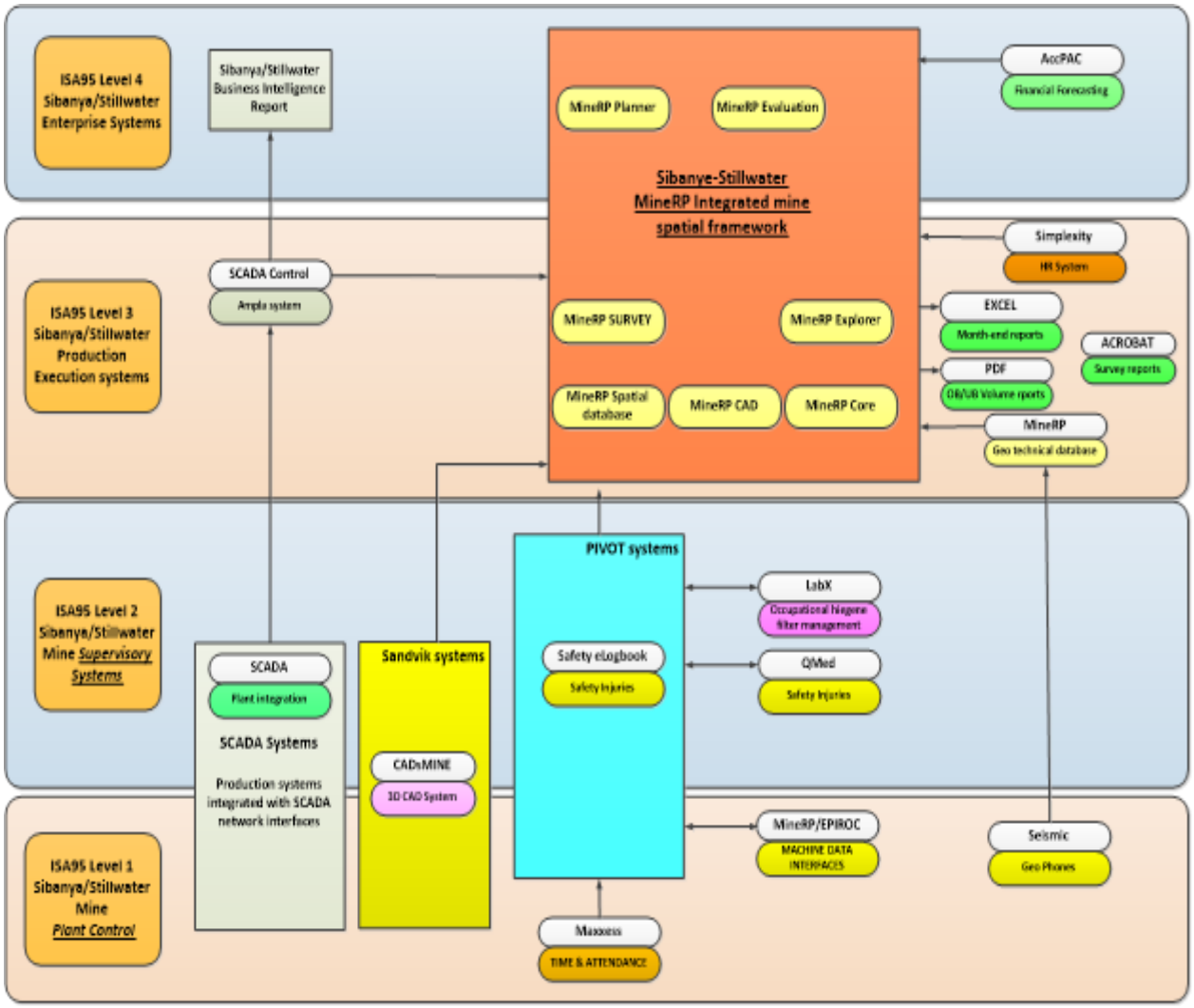

Figure 6: Solution framework implemented.

The Sibanye-Stillwater ERP platform is unique as it also integrates with the Pivot electronic shift-boss electronic logbook (eLogbook) system. This eLogbook platform also serves as a level 1,2 integration platform to collate information from the time-and-attendance system, occupational health and safety software as well as the QMed safety injuries system. The Pivot platform collate all these data sources and interface with the MineRP platform via an open API software interface.

6 CONCLUSIONS

The establishment of an integrated planning and reporting system platform was successfully performed at the "Khomanani" and "Saffy" shafts of the Rustenburg and Marikana sites. The collaboration between the various OEM's resulted in the creation of a vendor agnostic integrated ERP platform, with the capability to integrate seamlessly with any system that adheres to open API interfaces. The unique capability of the MineRP platform to integrate with the Pivot eLogbook system allows Sibanye-Stillwater to improve substantially on their short-horizon near-real time planning schedules, accurate down to the shift-level.

7 RECOMMENDATIONS

The possibility to develop a digitised mine, with an integrated ERP platform provides the capability to integrate more technologies to the integrated platform to test future emerging technologies. It is recommended that the MMP test mine be utilised as a future site to adopt an integrated ERP platform, similar to the Sibanye-Stillwater mine configuration. This would provide the availability of near-real time data to establish an operations control room capability, which could be used as a future experimentation and research platform. During this research project, it was observed that mine operations room ergonomics and layouts are not optimally designed, and that no clear principles have been established in this domain to enhance mine situational awareness principles.

8 WAY FORWARD

It is recommended that an integrated ERP platform be established at the MMP test mine for the purposes of research into integrated mine planning systems and the development of the future digital mine control room ergonomics and enhancement of control room principles to enhance operational situational awareness.

The final report is the last milestone deliverable for this work package.

9 LESSONS LEARNED

This research project demonstrated that the technical and enterprise engineering capabilities do currently exist in the RSA to develop and integrate mine operations enterprise platforms with the capability to integrate across various OEM vendor platforms to implement integrated planning platforms for mines.